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Anthropogenic Influence on Coyote (*Canis latrans*)

Winter Movements in Eastern New Brunswick

Mathieu Dumond,
Éric Tremblay,
Marc-André Villard

July, 2001
Report 034

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Parks Canada - Technical Reports in Ecosystem Science

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by

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July, 2001

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Canadian Cataloguing in Publication Data

Dumond, M., É. Tremblay and M.-A. Villard

Anthropogenic influence on coyote (*Canis latrans*) winter movements in Eastern New Brunswick

(Parks Canada – Technical reports in ecosystem science; no. 34)
Includes an abstract in French.
Includes bibliographical references and an index.

ISSN 1200-3298; report no. 34
ISBN 0-662-29980-9
Catalogue No. R61-2-34-2001E

1. Coyotes – Wintering – New Brunswick – Kouchibouguac National Park.
2. Coyotes – New Brunswick – Kouchibouguac National Park – Geographical distribution.
3. Coyotes – Handling – New Brunswick – Kouchibouguac National Park.
I. Tremblay, Éric.
II. Villard, Marc-André, 1963-.
III. Parks Canada. Atlantic Region.
IV. Series: Technical reports in ecosystem science ; no. 34.

QL737.C22D84 2001 599.77'25'0971522 C2001-980081-9

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102-02998/

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Abstract

Part I: From October 1995 to August 1996, we live-trapped and radio-tracked coyotes (*Canis latrans*) in the Greater Kouchibouguac Ecosystem. We used leghold traps during fall 1995, and spring and summer 1996. We used snares during winter, spring and summer 1996. Seventeen different coyotes were captured and 14 were fitted with a radio-collar. Overall, leghold traps and snares had an efficiency of 8.4 and 5.8 coyotes per 1000 trap*nights respectively. There was no by-catch with snares and 37.4 by-catches per 1000 trap*nights with leghold traps (57% red foxes, *Vulpes vulpes*).

Part II: Coyotes captured in Kouchibouguac National Park had larger home ranges ($P \leq 0.083$), and were less active ($P \leq 0.005$) compared to resident coyotes captured outside the Park. Coyotes captured in the Park were located from 40 to 50% of the time outside the Park boundaries. They were more active during the daylight ($P = 0.076$) whereas the activity of coyotes monitored outside the Park was not different between night and day ($P = 0.222$). Coyotes traveled greater distances at night ($P = 0.001$) and traveled daily a minimum of 20.2 km. The size of coyote home range was positively correlated with the percentage of wetlands and negatively correlated with the percentage of forest regeneration.

Our data suggest that, during winter, the Park represent a suboptimal habitat for coyotes. Moreover, it seems that the Park can not support a viable coyote population nor represents a source population for the region.

Key words: Anthropogenic perturbation, *Canis latrans*, Capture, Coyote, Movements, Protected area.

Résumé

Partie I : D'octobre 1995 à août 1996, nous avons capturé et radio-pisté des coyotes (*Canis latrans*) dans le Grand Écosystème de Kouchibouguac. Nous avons utilisé des pièges à patte en automne 1995, et durant le printemps et l'été 1996. Nous avons utilisé des collets en hiver , au printemps et en été 1996. Dix-sept coyotes ont été capturés dont 14 ont été équipés d'un collier émetteur. Globalement, les pièges à patte et les collets ont eu une efficacité de 8.4 et 5.8 coyotes par 1000 nuits*pièges respectivement. Il n'y a pas eu de prise accidentelle avec les collets mais 37.4 prises accidentelles par 1000 nuits*pièges avec les pièges à patte (dont 57% de renards roux, *Vulpes vulpes*).

Partie II : Les coyotes capturés dans le Parc national Kouchibouguac avaient des domaines vitaux plus grands ($P \leq 0.083$) et étaient moins actifs ($P \leq 0.005$) que les coyotes capturés hors du Parc. Les coyotes capturés dans le Parc ont été localisés hors du Parc dans 40 à 50% des cas. Ils étaient plus actifs le jours ($P = 0.076$) alors que le rythme d'activité des coyotes hors du Parc était similaire le jour et la nuit ($P = 0.222$). Les coyotes parcouraient de plus grandes distances durant la nuit ($P = 0.001$) et parcouraient journalièrement un minimum de 20.2km. La taille des domaines vitaux était positivement correlée avec le pourcentage de zones humides et négativement corrélée avec le pourcentage de régénération forestière.

Nos données suggèrent que, durant l'hiver, le Parc représente un habitat de qualité inférieure pour les coyotes. De plus, il semble impossible que le Parc soutienne une population viable de coyotes ou constitue une source dans une dynamique de population de type "source puit".

Mots-clés : Aire protégée, *Canis latrans*, Capture, Coyote, Mouvements, Perturbations humaines.

Acknowledgements:

We are grateful to Peter Richardson who shared with us his trapping experience. Many thanks to Christian Fortin for his precious help and experience in the field. Nadine Thébeau collaborated to the radio-tracking part of this study. Thanks to Marco Dussault for his GPS and GIS expertise. Thanks to Arnold Vautour and Noël Fontaine, Park Wardens, for their backup while releasing bear cubs. Financial support was provided by Parks Canada, Kouchibouguac National Park, Université de Moncton, and Faculté des études supérieures et de la recherche de l'Université de Moncton. The quality of this report was greatly improved by the comments of two anonymous reviewers.

Part I: CAPTURE, IMMOBILIZATION, AND BY-CATCHES (October 1995 - August 1996)

Introduction

Numerous wildlife studies require the capture and restraint of animals for a wide variety of reasons. In such cases, field biologists have to reach a compromise between ethics, efficiency, and safety. Capture procedures and restrain methods are available for numerous furbearer species (see Novak 1987, Clark and Jessup 1992 for a review). Although field data become more and more available in the literature (Englund 1982, Van Ballenberghe 1984, Linscombe and Wright 1988, Onderka et al. 1990, Hubert et al. 1996, Phillips 1996, Phillips et al. 1996, Hubert et al. 1997, and others), injuries and by-catches are rarely reported in papers that do not specifically address new materials or methodology.

In general, cage traps would be the safest method to capture animals, reducing the risks of injury for both the animal and the public. Canids such as red foxes (*Vulpes vulpes*) and coyotes (*Canis latrans*) would be really difficult to capture with cage traps (De Almeida, 1987, Winter 1990). Thus other capture procedures must be considered increasing the risks.

During four periods from October 1995 to August 1996, we attempted to capture coyotes to fit them with radio-collars for the radio-tracking part of an extensive coyote study held in the Greater Kouchibouguac Ecosystem, New Brunswick, Canada. We reported here, the complete results of two capture and restrain procedures used on coyotes in eastern New Brunswick. We described the capture methods and their efficiency, by-catch management, and address recommendations for future studies needing to live-trap canids.

Materials and Methods

Capture Methods

General

Capture and immobilizing methods were approved by the Animal Care Committee, Parks Canada, and the New Brunswick Department of Natural Resources and Energy. From October 1995 to August 1996, we attempted to live-trap coyotes within and outside Kouchibouguac National Park, in a total area of about 2000 km². The study area was essentially woodlands (approximately 70 %). Details on the study area are provided elsewhere (Desloges 1980, Dumoulin et al. 1995, Dumond 1999, Dumond and Villard 2000). We used steel leg-hold traps (Skinner and Todd 1990, Phillips et al. 1996,

Hubert et al. 1997) and snares (Nellis 1968, Voigt and Berg 1987, Brent Patterson, personnal communication) that were modified to reduce injuries to both coyotes and by-catches. All working traps and snares were checked every morning between 4h30 am and 11h00 am to reduce the time an animal spends in the trap, and the risk of injuries.

For the first trapping period (with leg-hold traps) a professional trapper (P.Richardson) was in charge of the setting of the traps, and two persons were in charge of the immobilization procedure. During the second period the snares were set by the professional trapper (P. Richardson) but only one person (M. Dumond) was doing the check every morning. For the third and forth periods, M. Dumond was setting the traps and the snares, and for the immobilization we usually were a crew of three people in the field.

We recorded the capture efficiency as the number of coyotes (or by-catches) per 100 trap*nights (TN). Trap*nights represent the number of trapping night multiplied by the number of active traps. This number was corrected by subtracting 1/2TN for each by-catch or sprung trap (or snare).

Leg-hold traps

Most of the traps were #3 Northwoods(R) leg-hold traps or equivalent with four coil-springs. The jaws were enlarged by a rolled steel lamination strip, and offset (Fig.1a). Pan tension was increased by tightening the tension-screws on the pan hinges to reduce the probability of catching small non-target species. The traps were anchored to the ground with a 0.75-meter aircraft cable (3mm in diameter) and a one-meter chain containing several swivels to reduce the risk of breaking leg. We also used steel drags and a 1.75-meter chain sets with also swivels along the chain. Bait was usually placed in a hole (about 10 to 15 cm in diameter) behind the trap. The bait was usually old meat and we also used fox and coyote urine as lure. Typical setting is illustrated on Figure 1b.

Traps where set along dirt roads, logged areas, old gravel pits, dumps and fields outside the park and along old dirt roads, old fields and bicycle trails within Kouchibouguac National Park.

Snares

Snares were made of 2.5 m galvanized 7x7 aircraft soft cable (about 2.4 mm in diameter) with a Cam-lock™ and a stop making a 31 cm loop to restrain the coyote without choking it. The snare was successfully tested on a coyote-size dog. Snares were set to reduce the

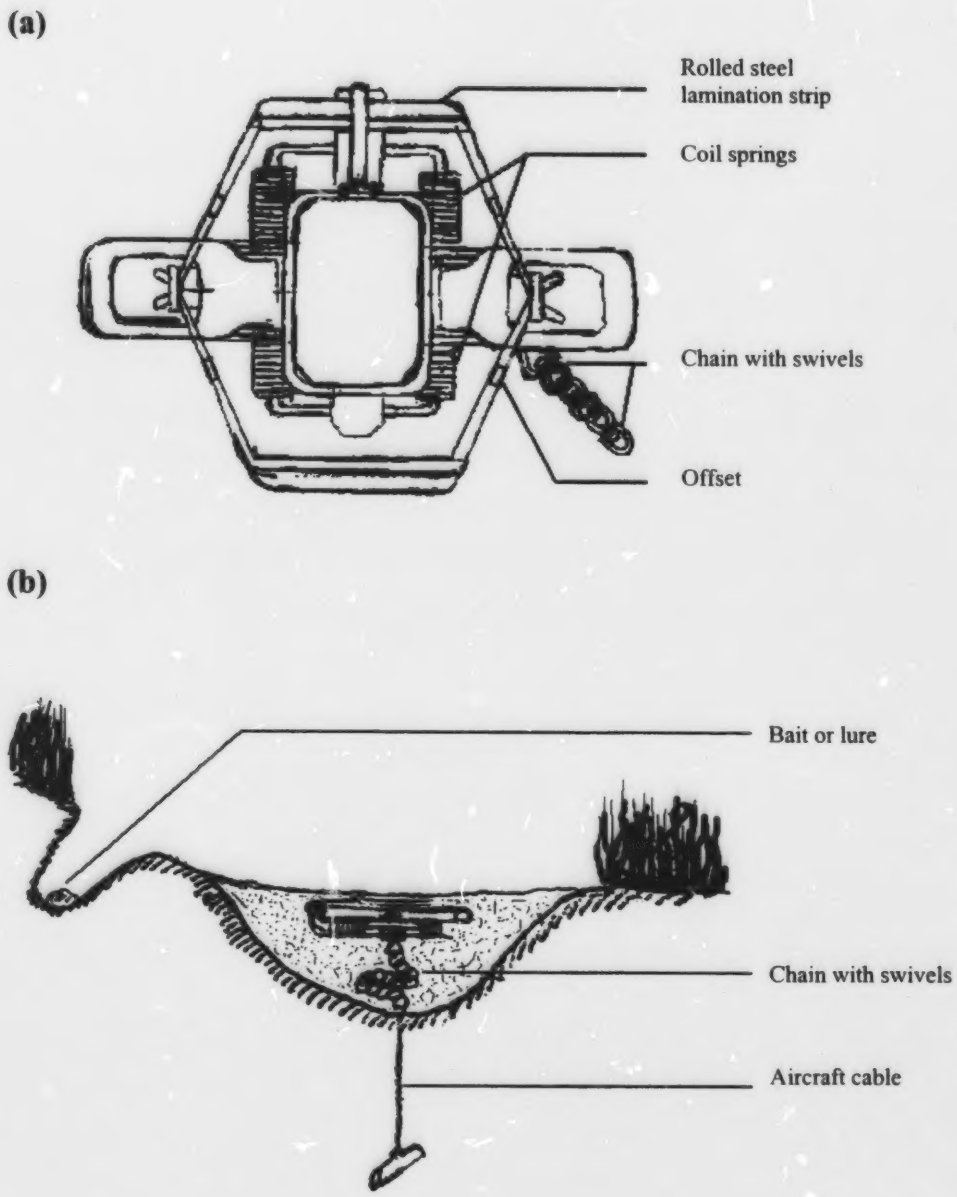

Figure 1: Leg-hold trap modifications (a), and typical setting (b) used to live-trap coyotes in the Greater Kouchibouguac Ecosystem.

risk of by-catches. The snares were set along coyote pathways (visible in the snow) or around bait (road-kill carcasses or carcasses from the trapping season). Snares were checked every day from a distance with binoculars to minimize sent and tracks that could reduce the efficiency. This also minimized the risk of having snares stolen by humans.

Immobilization and release methods

Leg-hold traps

Coyotes in leg-hold traps were first restrained with a snare-pole by putting the loop around the neck, and maintaining the pole along the shoulder and the rear leg. Coyote body-weight was visually estimated. Then, the coyote was injected with (0.15 to 0.20 ml per kg of animal weight, Clark and Jessup 1992) Ketamine Hydrochlorid (Ketaset[(c)] 100mg/ml). The injection was made in the muscle part of the rear leg. After induction, the coyote was released from the trap and brought on a blanket and artificial tears were applied to prevent the cornea from drying. We checked the leg that was caught in the trap and the general body condition of the animal. Then we put the radio-collar on and took the body measurements. The animal length was taken from the tip of the nose to the base of the tail (body length) and to the last vertebra of the tail (total length). The chest height was measured from thefront leg paw to the chest. The blanket set with ropes was used to weigh the animal with a suspended scale. During all the manipulations, care was taken to avoid any strong stimuli (noise, movements, light, touch, smell). A piece of blanket covered the eyes most of the time because Ketamine usually makes the animal very sensitive to the light when they wake up. However, the animal was sensless while under the effect of Ketamine. These precautions permitted extended work time, and made recovery easier for the animal. When complete, we transferred the coyote on the blanket in an open area for recovery but also with close cover to allow the coyote to hide until fully recovered.

Snares

Animals were not immobolized during the winter snaring period, due to the risk of hypothermia and because it was the breeding season. Also during this period, only one person (M. Dumond) checked the snares and the use of drug would have been hazardous. Because coyotes were already caught by the neck in the snares, they were easier to manipulate. Coyotes were grabbed by the tail and pulled until the cable of the snare was tight. Usually, the snare-pole was used to help maintain the coyote's head away from the

operator's hands. Adhesive tape (reinforced with fiberglass) or a rope were used to keep the jaws closed. Ropes were used to tie the four legs together. The following procedures were similar to those described previously except for release. The snare-pole was fitted around the neck of the animal and attached to a tree (to prevent animals escaping with their jaws still wrapped together). The ropes around the legs were taken off, and the tape or rope around the jaws was unwrapped. Finally the loop of the snare pole was released and the coyote was freed. Usually it took a few seconds before the animal realized that he was free.

Injury Evaluation

Visible injuries related to the capture procedure were recorded and classified in four categories describing the severity of injuries (Van Ballenberghe 1984):

- Class I injuries = slight foot and/or leg edema with no lacerations and no evidence of broken bones or dislocated joints; slight lip and gum injuries.
- Class II injuries = moderate edema with skin laceration 2.5 cm or less long, bones and joints as in class I; slight lip and gum injuries.
- Class III injuries = Skin laceration greater than 2.5 cm long with visible damage to underlying tissues, tendons intact, bone breakage limited to one phalanx or metacarpal; lip and gum injuries, and broken tooth.
- Class IV injuries = various combinations of deep, wide lacerations, severed tendons, broken bones, and joint dislocations; lip and gum injuries, and broken tooth.

For snared coyotes we adapted previous injury categories as follow:

- Class i injuries = slight lip and gum injuries.
- Class ii injuries = slight lip and gum injuries, and small laceration elsewhere.
- Class iii injuries = Lip and gum injuries, broken tooth, small laceration elsewhere, and slight edema due to strangulation.
- Class iv injuries = Same as class iii but with major edema due to strangulation.

Results

Coyotes

A total of 19 coyotes (including two recaptures) were captured from October 1995 to August 1996 (Table 1). The capture efficiency varied greatly from one trapping period to another (range from 0.48 to 1.36 coyotes / 100 TN, Table 1). For all periods together, leg-hold traps had a better capture efficiency than snares (0.84 compared to 0.58 coyotes / 100 TN). During fall 1995, 73% of the coyotes were captured during the first half of the trapping session (Fig.2). This is likely explained by

more inclement weather conditions during the second half of the trapping session. Moreover, official trapping and deer hunting seasons began from the end of October, increasing human presence around our trap-lines. Also, after several manipulations, traps may not have been odorless anymore.

The physical characteristics and data on immobilization of the coyotes are summarized in Table 2. Even for two coyote pups caught in August, the injuries caused by the traps were not more than type II (or ii). Gum and lip injuries occurred when the animal chewed either the trap or the surrounding vegetation. Only one coyote had a severe laceration (AF5) on the foot caught but with no broken bone nor joint dislocation. Generally, visible injuries were lower with snares than traps. However, for the two recaptured coyotes, and the four collared coyotes killed during the study, there was no sign of trauma related to their first capture.

The two coyote pups captured in August did not have any injuries. They were managed like foxes (i.e. grabbed by the tail and the neck) to release them from the trap. We did not fit them with a radio-collar because collars were too heavy and not designed to self-adjust with the growth of the neck circumference.

By-Catches

Although aiming for coyotes, we captured several other species that required modifications of our protocol. No by-catch was recorded with snares (Table 1). Due to the increased pan-tension in leg-hold traps, we captured relatively large non-target species reducing the risk of severe injuries.

Of 33 foxes captured, one was shot dead by hunters, and two had the leg caught broken due to the rolling up of the chain around the vegetation that prevented the swivels from working. The others were released without serious injuries (usually small cutaneous laceration that were treated with antiseptic ointment). Of the two foxes with a broken leg, one was released without intervention, and the other was euthanazied on site. All foxes were released by grabbing them by the tail and by the neck, while opening the trap with our feet.

We caught 10 striped skunks (*Mephitis mephitis*). Every time but once, we used a garbage can to cover the animal and just pull the leg with the trap outside, open the trap and lift the garbage can to release the animal. For obvious reasons, we also used the garbage can to release porcupines (*Erethizon dorsatum*).

Raccoons (*Procyon lotor*) were handle with a snare-pole. Also, bear (*Ursus americanus*) cubs were released with the snare-pole, but due to safety concerns, two Park

Table 1: Number of coyotes and by-catches, and trapping effort among trapping periods.

Session	October-November	February	June	August	Total
Number of nights	50	27	17	22	116
Type of traps [a]	T	S	T + S	T	T + S
Trap or snare*nights	1356	941	210 (T 112 / S 98)	150	2657 (T 1618/S 1039)
Correction [b]	1290	932.5	208 (T 111.5 / S 96.5)	147.5	2578 (T 1549/S 1029)
Coyotes captures	11	5	1 (snare)	2	19 (13/6)
Re-capture	1	1	0	0	2 (1/1)
By-Catches	56	0	1 (leg-hold trap)	1	58
Red Fox	33	0	0	0	33
Skunk	9	0	1 (leg-hold trap)	0	10
Porcupine	4	0	0	1	5
Raccoon	3	0	0	0	3
Bear Cubs	2	0	0	0	2
Domestic Cat	2	0	0	0	2
Hare	2	0	0	0	2
Crow	1	0	0	0	1
Sprung and locked traps	76	17	3 (snares)	4	100 (T 80/S 20)
Human disturbance	8				8
Bear	5			2	7
Coyote	3	4			7 (T3 /S 4)
Red Fox	3				3
Weather disturbance	44	12			56 (T 44/S 12)
Unknown	13	1	3 (snares)	2	19 (T 15/S 4)
Number of coyote per 100 trap*nights	0.85	0.54	0.48 (T 0/S 1.04)	1.36	0.74 (T 0.84/S 0.58)
Number of by-catch per 100 trap*nights	4.34	0.00	0.48 (T 0.90/S 0)	0.68	2.25 (T 3.74/S 0)

[a] T= leg-hold traps ; S= snares.

[b] See methods for explanations.

Table 2: Capture data from 17 live-trapped coyotes in the Greater Kouchibouguac Ecosystem from October 1995 to August 1996.

Date	Site	Trap/ Snare	Age	Sex	#	Drug dosage (ml/kg)	estimated weight (kg)	Drug injected (ml)	Time of injection	Duration of Anesthesia	Real weight (kg)	Body length (cm)	Total length (cm)	Neck circumference (cm)	Chest height (cm)	Body condition[c]	Caught leg[d]	Injuries
1995-10-10	OP[a]	T	J	F	0	0 15	8	1 2+0 6	7 59/8 20	?	10 9	88 0	122 0	28 5	-	G	Fl	I[b]
1995-10-11	IP	T	A	F	1	0 20	15	3 0	9 03	22mn	10 7	90 0	118 0	28 5	30 0	G	Fl	II
1995-10-13	IP	T	A	F	2	0 20	16	3 2	9 01	19mn	15 3	97 0	132 5	36 5	34 0	G	Fr	II
1995-10-13	IP	T	A	M	2	0 20	18	3 6	9 10	22mn	15 2	90 0	123 0	34 5	34 0	G	Rl	II
1995-10-17	OP	T	A	F	3	0 20	12	2 4+1 2	7 47/8 06	31mn	11 7	92 5	124 5	31 0	37 0	G	Fl	I
1995-10-18	OP	T	A	M	4	0 20	15	3 0	7 35	55mn	19 4	108 0	147 0	37 0	33 5	G	Fl	I
1995-10-20	OP	T	A	F	5	0 20	14	2 7	7 34	24mn	12 9	93 0	126 5	34 0	30 5	G	Fl	II+
1995-10-20	OP	T	A	M	2	-										G	?	0
1995-11-02	IP	T	A	M	6	0 20	15	3 0+1 0	7 36/8 03	never	19 2	90 0	129 0	37 0	35 0	G	Fl	II
1995-11-06	OP	T	A	M	7	0 18	17	3 1	8 49	34mn	14 5	96 5	135 5	33 5	35 5	M	Fr	II
1995-11-15	OP	T	A	-	-	0 13	15	2 0	5 28	?	15 0	-	-	-	-	B	Fl	II
1996-02-03	OP	S	A	M	8	-	12	-	-	-	17 4	90 0	130 5	37 0	-	G	-	ii
1996-02-11	OP	S	A	M	8	-	-	-	-	-	17 4	90 0	130 5	37 0	-	G	-	i
1996-02-11	OP	S	A	M	9	-	15	-	-	-	16 8	98 0	149 5	33 0	32 0	G	-	i
1996-02-28	OP	S	A	F	10	-	15	-	-	-	12 0	93 0	125 0	31 5	28 0	G	-	i
1996-02-28	OP	S	A	M	10	-	17	-	-	-	16 4	103 0	145 0	37 0	32 0	M	-	ii
1996-06-19	OP	S	A	M	11	0 13	15	2 0	8 45	?	17 0	103 0	143 0	33 0	32 0	G	-	i
1996-08-03	IP	T	P	M	12	-	-	-	-	-	-	-	-	-	-	G	Fr	I
1996-08-15	IP	T	P	M	13	-	-	-	-	-	5 75	88 0	65 0	-	-	G	Rl	I
Sample size				M/F		5/4	8/5	5/4		3/4	8/5	8/5	8/5	8/5	7/5			8/5
Average for Adult Males ± SD						0 18±0 03	15 5±1 9	3 1±0 8		37±5 1mn	17 0±1 7	97 3±7 0	137 8±9 7	35 3±1 9	33 4±1 5			1 6±0 5
Average for Adult Females ± SD						0 20±0 00	14 4±1 5	3 1±0 4		24±16 7mn	12 5±1 7	93 1±2 5	125 3±5 2	32 3±3 1	31 9±3 6			1 7±0 7

[a] OP= outside Kouchibouguac National Park ; IP= inside Kouchibouguac National Park.

[b] see methods for the description of injury categories. [c] G= Good, M= Medium, B= Bad. [d] F= Front, R= Rear, l= left, r=right.

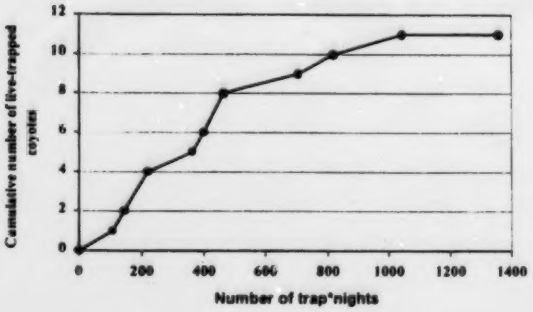

Figure 2: Relationship between the cumulative number of trap*nights and the cumulative number of live-trapped coyotes from October, 08th to November, 26th, 1995 in the Greater Kouchibouguac Ecosystem, New Brunswick.

wardens assisted us for backup with a dart-rifle and a 308 rifle. For house-cats (*Felis catus*) we used a blanket or an equivalent to avoid the claws. The two hare (*Lepus americanus*) and the crow (*Corvus corax*) were killed when the trap sprung.

Except for the two foxes that had a broken leg, injuries related to the trap were not more than type II.

Discussion

Overall, the leg-hold traps had higher capture efficiency than snares. But they had also a higher capture rate of non-target species and produced more injuries than did snares. Also, snares are lighter to carry in the field and easier to set. Coyotes taken in snares appeared to be easier to restrain, even without drug, than were coyotes caught in leg-hold traps.

It is difficult to compare our capture efficiency to other studies owing to the general lack of data concerning trapping effort or coyote densities in eastern Canada. However, during our study, capture efficiency varied from 0 to 1.36 coyote per 100 TN for leg-hold traps, and from 0.54 to 1.04 coyote per 100 TN for snares. In Alberta, Skinner and Todd (1990) reported a capture efficiency of 4.3 coyotes per 1000 TN with leg-hold traps, which is half our average (8.4 coyotes/1000 NT). Fortin and Huot (1995), in Forillon National Park, had a capture rate of approximately 3.1 coyotes per 1000 TN during summer and fall 1992. The capture efficiency may be influenced by several factors such as trapper experience, coyote population density, season, landscape, location of sets, duration of the trapping session, and luck. During the study, the winter coyote population density was estimated to be 1 coyote per 10 km² (Dumond 1997). Our trapping area represented approximately 2000 km² in which it could be assumed to live approximately 200 yearling and adult coyotes. Then, excluding the two coyote pups, we would have caught 7.5% of the coyote population (≥1 year old) in our study area with a total of 1618 leg-hold trap*nights plus 1039 snare* nights.

Several factors may have reduced injuries and by-catches. The increased pan-tension reduced considerably the number of small non-target species (foot-prints observed on the pan site) that would probably have been injured by the trap. Phillips and Gruver (1996), using a pan tension device, reported a reduction in capture of non-target species, without reducing the traps effectiveness in capturing coyotes. The crow and the two hares were caught at the end of the fall trapping season when the screw of the pan hinge had loosened. The presence of swivels along the chain of the traps may have reduced the risks of broken legs. The two cases of broken leg in foxes were due to the rolling up of the chain around the vegetation (making the swivels ineffective). Several studies reported broken legs in coyotes caught with unpadded traps (Onderka et al. 1990, Phillips et al. 1996, Hubert et al. 1997). Phillips et al. (1996) reported only 3% of individuals (N=59) with fractures with the #3 Northwoods$^{(R)}$ traps (with enlarged and offset jaws). Although, we did not use padded-jaw leg-hold traps, we had very few severe injuries and no broken leg among coyotes. Most of trap research has been developed in the western part of the coyote distribution. Eastern coyotes are recognized to be larger than their counterpart of the west (Voigt and Berg 1987). In their western range, adult coyote usually weigh between 8.2 to 13.6 kg. The coyotes we captured weighted an average of 17.0 kg and 12.5 kg for males and females respectively (Table 1). This may explain that, even with unpadded leg-hold traps, we had a lower rate of injuries. Although new generations of padded traps have been found to be nearly as efficient as unpadded traps in capturing western coyotes (Linscombe and Wright 1988, Skinner and Todd 1990, Linhart and Dasch 1992, Phillips and Mullis 1996), it is not clear that it would be the same for larger eastern coyotes (P. Richardson, personal communication). Because animal welfare is a major concern in wildlife research and particularly in National Parks, trap performances and related injuries should be tested more extensively for canids in eastern Canada and northeastern United-States.

Part II: ANTHROPOGENIC INFLUENCE ON COYOTE WINTER MOVEMENTS IN A FOREST LANDSCAPE OF EASTERN NEW BRUNSWICK

Introduction

Coyotes were first recorded in Kouchibouguac National Park in October 1980 (Morton and Savoie 1983). This new predator in eastern New Brunswick ecosystems has brought concerns about its potential impact on native species. Also, it raised the question of the role of a protected area such as Kouchibouguac National Park in the dynamics of coyote populations. Does the Park act as a source for coyote populations? Do coyotes use the surrounding human-altered areas more intensively than the protected area?

Protected areas usually are too small to protect medium to large carnivores. Forbes and Theberge (1996) found that 68% of wolf mortality (n=41) occurred outside the boundaries of Algonquin Provincial Park. More than half (56%) of wolf mortality was human related. Thurber et al. (1994) found that wolves of the Keina Peninsula Refuge (Alaska) avoided settled areas and active roads.

This relationship could be inverted for coyotes (*Canis latrans*) as human activities may provide supplemental source of food. Coyotes of the Saguaro National Monument, Arizona, often foraged in the bordering suburban developments (McClure et al. 1995). Also, clear-cutting allows fruit-bearing plants to grow thereby attracting potential prey of coyotes (Toweill and Anthony 1988). Bekoff and Wells (1986) found that hunter-killed Elk (*Cervus elaphus*) carcasses were a major source of winter food for coyotes of the Grand Teton National Park. In a forest landscape of New Hampshire, Oehler and Litvaitis (1996) found an increase of wild canid (i.e. coyotes and red foxes, *Vulpes vulpes*) densities as the proportion of human-dominated habitats increased from 7 to 27% of the landscape.

Dumond et al. (*submitted manuscript*) found that diversity of winter diet was higher in coyotes using Kouchibouguac National Park (KNP) compared to those foraging exclusively outside KNP, which may indicate that during this season, the protected area represented a suboptimal habitat for coyotes (MacCracken and Hansen 1987; O'Connell et al. 1992). Moreover, track transects

indicated higher snowshoe hare (*Lepus americanus*) activity inside KNP than outside KNP, yet, the proportion of this prey was significantly higer in coyote scats collected outside KNP than within KNP (Dumond et al. *submitted manuscript*). The higher rate of forest pertubation outside KNP may increase snowshoe hare vulnerability to coyotes (Keith et al. 1993). Thus, we would expect that coyotes of KNP spend more time, at least seasonally, outside the park to use supplemental food sources generated from human activities and perturbations. Also, if localized human activities induce supplemental sources of food for coyotes we would expect coyote home ranges to be smaller outside KNP than inside KNP.

To assess the anthropogenic influence on coyote winter movements, we compared the home ranges, movements, and activity of radio-collared coyotes within and outside KNP.

Study Area

The study area constitute a 40x45 km area (center: 46°49'N, 65°03'W) within the Greater Kouchibouguac Ecosystem (GKE), a large region centered on Kouchibouguac National Park (KNP), in eastern New Brunswick, Canada. The GKE is representative of the Maritime Plain Natural Region (Tremblay 1997) and contains a range of forest types typical of the Acadian Forest, associated freshwater systems, and extensive peatlands (Tremblay and Beach 1994). The region is characterized by a flat terrain, gently sloping towards Northumberland Strait (Desloges 1980). The climate is typical of the eastern coast of the continent, with an average annual temperature of 5°C and average precipitation of 979 mm (with 18.8% as snow corresponding approximately to 1.8 meter). Winter temperatures (December to March) average -7.1°C (Desloges 1980).

The study area encompasses two sampling areas, a protected area (KNP, 238km²) and the unprotected adjacent areas (OP). Forested area represented approximately 70% of the two sampling areas. Logging and peat extraction were the main human activities outside the Park. A few farms are also scattered through the area, mainly along rivers. During the winter, country skiing is the principal human activity in the Park, but it is restricted to areas were we did not have any radio-collared coyotes. Land cover differences between the KNP area and surrounding areas were described elsewhere (Dumoulin et al. 1995, Dumond 1999). The two sampling areas mainly differed (G-tests, $P<0.01$, Dumond 1999) by

the percentage cover of forest regeneration (higher outside KNP), the percentage cover of wetlands (higher in KNP), and the percentage of areas less than 500m from human disturbances and less than 100m from roads (higher outside KNP).

Methods

Capture procedures were described in the first part of this report. When immobilized, coyotes were fitted with a permanently attached VHF radio-collar (Austec electronic systems Ltd., Edmonton, Alberta) weighing approximately 250g, and transmitting on an individual frequency on the 150.400-150.800 Mhz range. The coyotes were classified according to estimated age (A= Adult, J= Juvenile <2 years old, P = pup), sex (M= Male, F= Female) and capture order. Each transmitter had a mortality sensor set at 15 minutes though it could be used as activity sensor (after 15 minutes of immobility the signal pattern changed but returned to its original pattern as the animal begin to move again). The battery of each radio-collar was expected to last about one year. After release, each coyote signal was searched at least every two weeks while driving the road network of the study area with a pick-up truck equipped with two 2-elements Yagi antenna oriented toward each side of the road. When a signal was picked up, the exact location of the coyote was determined by traditional triangulation, using a hand held 3-element antenna, and at least two bearings separated with a maximum of 5 minutes to reduce the error due to animal movements (Schmutz and White 1990). Sequential sessions also were done, where the same coyote was followed for several hours. We recorded, on a 1:50000e map, each site where a bearing was taken. The exact position of each site was determined with a GPS (Trimble ProXR with differential correction). We also obtained a few localizations using an aircraft (Cesna 172) equipped with two 2-elements Yagi antennas. Each location was computed with LOCATE II software package (Nams 1990). When more than three bearing were taken for a location, we removed the more deviant bearing to obtain a more precise estimation of the location (minimum 95% error ellipse). Location data were imported in CALHOME 1.0 software package (Kie et al. 1994). We used the 95% Adaptative Kernel (95%AK), and the 100% and 95% Minimum Convex Polygon (100%MCP and 95%MCP) estimators of home ranges to allow comparisons with other studies.

The minimum daily movements were estimated for territorial coyotes from

sequential tracking sessions, and successive locations of the same coyote less than 36 hours apart. The distance between two successive locations was divided by the time spent between those two locations. We classified the data in 2 daily-periods (08h00 to 17h59 and 18h00 to 07h59) which corresponded roughly to daylight and night periods during the tracking months. Activity pattern was determined by pooling all the coyote activity data classified in the same 2 periods of the day. We determined the percentage of active locations on the total number of locations per period of the day. For movements and activity patterns, we also separated data collected within Kouchibouguac National Park and outside the Park. Because there was some variations for activity and movements between the two periods of the day, we used the average of the two periods weighted with the duration of each period to assess the 24 hours activity and the sum of the two periods to assess the movements during a 24 hours period. Activity and movements data would not have been independent for individuals located together, thus we used the mean of the two animals.

We imported the localization data in SPANS-Explorer 7.1 (TYDAC Research Inc. 1997) to analyze the differences in landscape use by the coyotes captured within Kouchibouguac and outside. For the landscape analysis, we used only general land-cover categories (Forest, forest regenerations, logged areas and fields, urban and roads, wetlands) of a reclassified LANDSAT-TM image of the GKE.

We used the term KNP-coyotes to designate coyotes captured within KNP, and OP-coyotes to designate coyotes living exclusively outside KNP during the study. IP-localizations designate localizations of KNP-coyotes within the boundary of KNP, and OP-localizations regroups all coyote locations outside KNP (KNP-coyotes + OP-coyotes).

Movement and activity data were statistically tested for differences between KNP-coyotes and OP-coyotes and between periods of the day. We used t-tests to compare means (movements, Systat 7.0), and G-tests with William's correction to compare frequencies (activity, Sokal and Rohlf 1981). For home ranges, we used one-tailed t-tests to test the hypothesis that the mean size of OP-coyote home ranges was smaller than the mean size of KNP-coyote home ranges. For all tests the significant level was set for $P \leq 0.1$. We felt that it was important to reduce the type II error (β) owing to the importance for Park managers not to

conclude that KNP has no influence on coyote winter movements when it does.

Results

Coyote History and Relationships

Fourteen coyotes were radio-collared from October 10th, 1995 to June 19th, 1996 (Table 1). Four coyotes were capture within Kouchibouguac National Park (AF1, AF2, AM2 and AM6). AF1 and AM6, and AF2 and AM2 formed adult pairs. AM2 was recaptured once outside KNP at the same capture site that JF0 and AF3 but we were not able to assess the relationships between AF3, JF0 and the AM2-AF2 pair owing to the early death of AF3 and the failure of JF0 transmitter. When captured and while radio-tracked, AM8 was associated with at least one other coyote. There also was a possible relationship between AM8 and AM11 because we found the chewed collar of AM8 at the capture site of AM11. AM9 was probably associated with two other coyotes according to the tracks in the snow at the capture site. AM10 and AF10 formed a pair. There was no substantial information on the social status of AM4, AF5 and AM7.

One transmitter failed just after being put on JF0; two coyote signals were lost for unknown reason less than a week after release (AF5 and AM11); the signal of AM4 and AF3 was lost after one month and AF3 was trapped one month later; one coyote was trapped less than one month after release (AM7); one collar was found in the wood near a dirt road, cut off with a knife 1.5 month after it was fit on AF10 (human related cause of death was assumed); the signal from AM10 was lost 1.5 month after release; two transmitter signals rapidly became very low and were lost within 3.5 months (AM2 and AF2); four coyotes were monitored for at least 3 months with at least 20 localizations (AF1, AM6, AM8, and AM9) (see Table 3). AF1 was chased and killed by snowmobiles on a bog outside Kouchibouguac National Park, and we lost the signal from AM6 3.5 months after release. The collar of AM8 was found chewed at the capture site of AM11 in June 1996. The signal from AM9 was lost by the end of May 1996. AM10 was shot-dead one year after its first capture in the same area he was monitored. AM10 was severely affected by mange and would probably not have survived the winter.

Home ranges

AF1 and AM6 were captured at the same capture site, 3 weeks apart. During the period when they were both monitored, they

Table 1: Duration of the monitoring and number of localizations for each radio-collared coyote.

ID	date of capture	Location of capture	frequency 150. MHz	Date of last signal	Date of death	Cause of death	Number of monitoring days	Number of locations
JF0	19951010	OP*	.500	19951010			0	1
AF1	19951011	IP	.525	19960310	19960311-12	Snowmobile	151	37
AF2	19951013	IP	.700	19960116			107	10
AM2	19951013	IP	.675	19960116				
AF3	19951017	OP	.625	19951102	19951206-07	Snared	15	3
AM4	19951018	OP	.600	19951119			31	4
AF5	19951020	OP	.650	19951022			2	2
AM6	19951102	IP	.575	19960213			102	31
AM7	19951106	OP	.725		19951201	Snared	24	6
AM8	19960203	OP	.750	19960615			132	40
AM9	19960211	OP	.775	19960529			107	22
AF10	19960228	OP	.550	19960419	< 19960529	Human?	50	11
AM10	19960228	OP	.625	19960419	19970208	Mange/ shot		
AM11	19960619	OP	.725	19960620			1	1
Mean							62.8	14

*OP= outside Kouchibouguac National Park ; IP= inside Kouchibouguac National Park.

were located together on 53% of the time when they were both relocated (N=17). AF2 and AM2, and AF10 and AM10 were captured at the same capture-site, the same day respectively, and were always re-located together when both located (N=5 and N=8 respectively).

We did not analyze the home ranges of coyotes for which we had less than 10 localizations (Fig.1). We analyzed separately the home range of AF1 and AM6 owing to their relative independence. But we considered AF2 and AM2 (AMAF2), and AF10 and AM10 (AMAF10) as one individual, estimating the home range of each pair instead of individuals. The relationship between the home range area and the number of localizations tend to

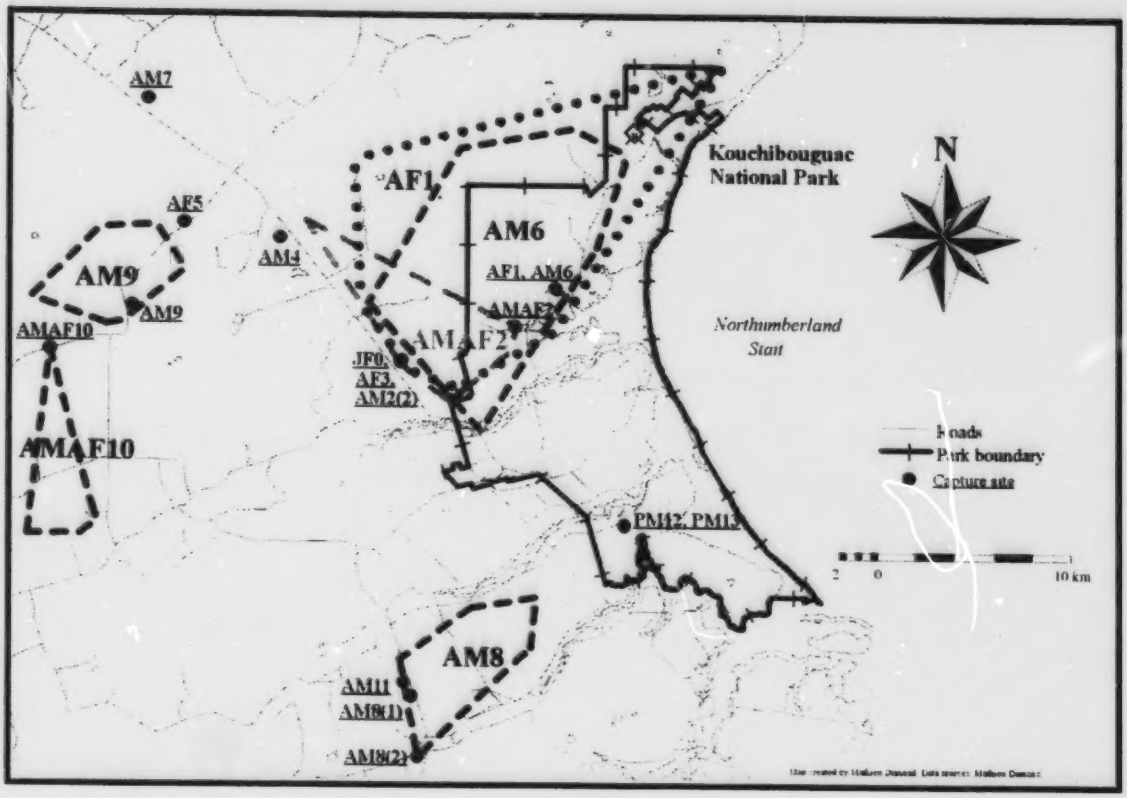

Figure 1: Coyote capture sites and home ranges (100% minimum convexe polygon) from October 1995 to June 1996 in the Greater Kouchibouguac Ecosystem, New Brunswick, Canada.

reach an asymptote for AF1, AM6, AM8, AM9, and AMAF10 (Fig.2). Although the curve of AMAF2 did not reach the asymptote, those data were used but considered to represent a minimum area.

The average area of winter home ranges of the coyotes followed more than three months and for hich we had more than 20 locations (AF1, AM6, AM8, and AM9; Table 2) was 116, 84, and 61 km² with 95% AK, 100% MCP, and 95% MCP respectively.

The average size of home ranges for coyotes that used KNP (N=3; AF1, AMAF2, and AM6) was 151, 108, and 80 km² (95% AK, 100% MCP, and 95% MCP respectively) compared to 32, 23, and 19 km² (95% AK, 100% MCP, and 95% MCP respectively) for coyotes monitored exclusively outside the Park (N=3; AM8, AM9, and AMAF10).

According to the few studies in the coyote northeastern range, home range size of male coyotes do not vary significantly or

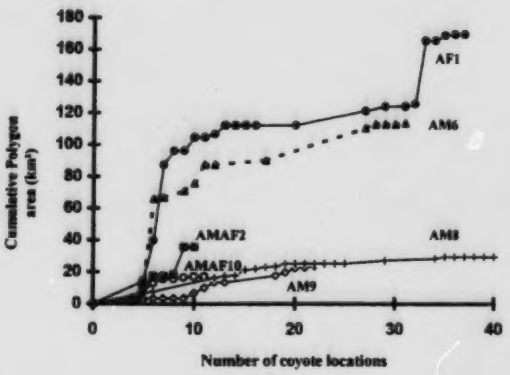

Figure 2: Relationships between home range size (100% Minimum Convex Polygon, km²) and the number of locations for individual coyotes in the Greater Kouchibouguac Ecosystem, NB.

tend to increase from breeding to nursing periods (Caturano 1983, Winter 1990). From gestation to nursing period, female home range size tend to decrease (Caturano 1983, Parker and Maxwell 1989). However, during nursing, we did not have monitored female inside KNP, and we combined the locations of both members of the pair monitored outside KNP. Although, the periods of monitoring of our coyotes does not completely overlap, we felt appropriate to test the hypothesis that OP-coyote home ranges were smaller than KNP-coyote home ranges.

Table 2: Home range estimates of six radio-tracked coyotes in the Greater Kouchibouguac Ecosystem (October 1995 - June 1996).

	Beginning of monitoring (year-month-day)	End of monitoring (year-month-day)	N	95% AK[a] (km²)	100% MCP[a] (km²)	95% MCP[a] (km²)
AF1	19951011	19960310	37	239	169	129
AMAF2	19951013	19960116	10	61	36	36
AM6	19951102	19960213	31	155	114	74
AM8	19960203	19960615	40	38	29	22
AM9	19960211	19960529	22	32	24	19
AMAF10	19960228	19960419	11	28	17	17
Mean ± SE			6	92 ± 35	65 ± 25	49 ± 18
Mean(>20)[b] ± SE			4	116 ± 50	84 ± 35	61 ± 26
Mean (KNP-coyotes)[c] ± SE			3	151 ± 51	106 ± 39	80 ± 27
Mean (OP-coyotes)[d] ± SE			3	32 ± 3	23 ± 4	19 ± 1
AF1 (1st asymptote)[e]	19951011	19960213	32	199	125	116

[a] AK = Adaptative Kernel ; MCP = Minimum Convex Polygon.

[b] Mean for coyotes with more than 20 localizations.

[c] Mean for coyotes using Kouchibouguac National Park.

[d] Mean for coyotes exclusively located outside Kouchibouguac National Park.

[e] See explanation in the result section.

Although, we have no evidence of any relationship, the home range of AF1 (100%MCP) seemed to reach a first plateau at 125 km² but increased dramatically to 169 km² juste after we lost the signal of AM6. Therefore, we also estimated the home range of AF1 only from locations before February 13th, date of the last location of AM6 (Table 2). The average area of winter home ranges of the coyotes (AF1, AM6, AM8, and AM9) was then 106 ± 42, 73 ± 27, and 58 ± 23 km² with 95% AK, 100% MCP, and 95% MCP respectively. And the average size of home ranges for coyotes that used KNP (N=3; AF1, AMAF2, and AM6) was 138 ± 41, 92 ± 28, and 75 ± 23 km² (95% AK, 100% MCP, and 95% MCP respectively). When comparing mean home range size estimates (95%AK, 100%MCP, and 95%MCP) of KNP-coyotes and OP-coyotes, with both estimates of AF1 home range size, OP-coyotes home ranges were significantly smaller (one-tailed t-tests, $P \leq 0.083$).

Movements

Minimum distance traveled was assessed from successive locations less than 36 hours apart for five territorial coyotes (AF1, AM6, AM8, AM9, and AMAF10). Because minimum distance traveled were similar for KNP-coyotes and OP-coyotes ($t_{(48)}=0.305$, $P=0.761$), we pooled all data to compare their movements between periods of the day (Table 3).

Table 3: Minimum traveled distance by coyotes in the Greater Kouchibouguac Ecosystem (January - April 1996).

	N	Number of coyotes	km/h	Estimated movement
KNP-coyotes [a]	22	2	0.25	6.0 km/24h
OP-coyotes [a]	28	3	0.18	4.4 km/24h
IP-localizations [b]	11	2	0.21	5.0 km/24h
OP-localizations [b]	39	5	0.21	5.1 km/24h
08h00-17h59	6	2	0.41	4.1 km/10h
18h00-07h59	27	3	1.15	16.2 km/14h
Weighted mean			0.84	20.2 km/24h

[a] KNP-coyotes = coyotes using Kouchibouguac National Park ; OP-coyotes = coyotes located exclusively outside KNP.

[b] IP-localizations = localizations within KNP ; OP-localizations = localizations outside KNP.

Coyotes traveled significantly greater distances during the night ($t_{(29.5)}=3.867$, $P=0.001$). The estimated daily minimum distance was 20 km. However, when pooling all the data regardless of the period of the day, successive locations were separated by an average of 5 km/24h. KNP-coyotes tended to increase their daily travelling distance outside KNP ($t_{(10.5)}=1.800$, $P=0.101$).

Table 4: Percent (%) of active locations for 10 monitored coyotes [a] from October 1995 to May 1996 in the Kouchibouguac Greater Ecosystem, NB, Canada.

	Overall sample	OP-coyotes	KNP-coyotes	All coyotes relocated outside KNP	KNP-coyotes relocated outside KNP	KNP-coyotes relocated wthin KNP	Males	Females
08h00-17h59	63.1 (84)[b]	64.3 (49)	61.4 (35)	65.7 (67)	69.4 (18)	52.9 (17)	61.9 (63)	63.3 (30)
18h00-07h59	61.6 (43)	77.8 (27)	34.4 (16)	68.1 (36)	38.9 (9)	20.0 (5)	59.6 (47)	55.6 (18)
Weighted Mean [c]	62.2 (127)	72.2 (76)	45.7 (51)	67.1 (103)	51.6 (27)	33.7 (22)	60.6 (110)	58.8 (48)

[a] Except for comparisons between males and females, when coyotes from a pair where located together, we considered activity as the mean of the two individuals.

[b] Sample size in the brackets.

[c] Weighted mean = (08h00-17h59 period + 18h00-07h59 period)/2

Activity patterns

For activity pattern, we pooled all the locations of the 10 coyotes for which we had records of activity (AF1, AF2, AM2, AM4, AM6, AM7, AM8, AM9, AM10, and AF10). Overall, the coyotes were active 62% (n=127) of the time (Table 4). There was no difference (P=0.804) in activity between males (61%, n=110) and females (59%, n=48). When comparing the percentage of active records outside and within Kouchibouguac National Park, and for OP- and KNP-coyotes, we obtained a significant difference (G_{adj}=7.875, df=1, P=0.005, and G_{adj}=9.059, df=1, P=0.003, respectively). However, KNP-coyotes did not seem to modify their activity according to their location within or outside KNP. KNP-coyotes were more active during the daylight (08h00 - 17h59, G_{adj}=3.144, df=1, P=0.076) while OP-coyotes seemed to be active more continuously during the 24 hours period (G_{adj}=1.490, df=1, P=0.222). However, this could reflect a difference in activity rate between early and late winter rather than between KNP-coyotes and OP-coyotes owing to the difference in sampling periods.

Habitat composition of home ranges

AFI, AM6, and AMAF2 were relocated outside KNP boundaries in 40, 41, and 50% of the time, respectively. Forested habitats constituted most of coyote home ranges (Fig.3).

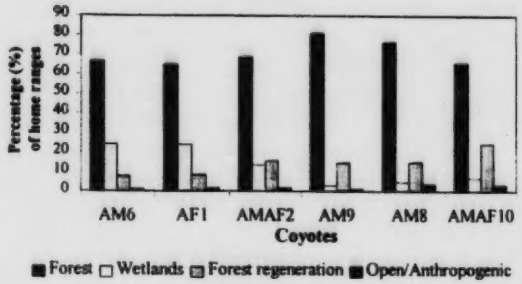

Figure 3: Habitat composition of coyote home ranges during winter 1995-1996 in the Greater Kouchibouguac Ecosystem, NB.

The size of home ranges was negatively related to the proportion of forest regeneration areas within the home range (R^2=0.8, $y = 0.0012x^2 - 0.2935x + 24.592$, Fig.4), and positively related to the proportion of wetlands within the home range (R^2=0.9, $y = -0.0014x^2 + 0.393x - 2.2418$, Fig.4).

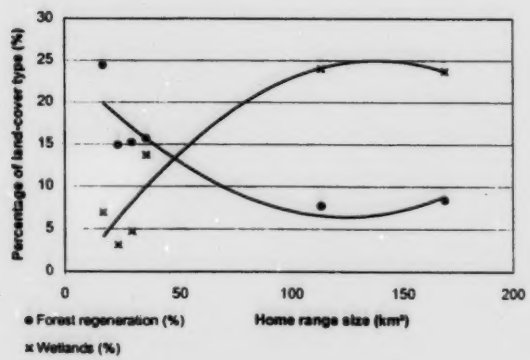

Figure 4: Relationships between coyote home range size (100% Minimum Convex Polygon, km²) and the percentage of forest regeneration and wetland areas (% of the home range).

When excluding the wetland areas in coyote home ranges, we still obtained a significant difference in home range size between OP-coyotes and KNP-coyotes (P=0.084).

Discussion

The winter home range of the coyotes we monitored fell within the upper range of areas generally reported during winter in northeastern USA (Harrison et al. 1989, Major and Sherburn 1987, Winter 1990) and eastern Canada (Parker and Maxwell 1989, Fortin and Huot 1995, Patterson 1995). Larger sample sizes would probably have reduced values for 95%AK and 95%MCP by allowing the exclusion of more extra-territorial locations. Conversely, our small sample sizes may have resulted in a conservative estimation of the home ranges. However, the fact that the estimated areas of home ranges seemed to reach an area-asymptote, makes us confident that our data are representative of the actual situation in our study area.

Early winter home ranges of coyotes using KNP were significantly larger than late winter home ranges of coyotes using exclusively the outside of the Park. The monitoring periods of KNP-coyotes and OP-

coyotes did not completely overlap and a seasonal bias might have affect our data. However, we mostly monitored territorial males or pairs for which home range size usually does not vary or tends to increase from breeding to nursing (see Bekoff and Wells 1986, Caturano 1983, Winter 1990). Therefore, although, KNP-coyotes were monitored during early winter while OP-coyotes were monitored during late winter, we think that the difference we observed may have been even greater with more overlapping monitoring periods.

Home range size increased with the proportion of wetlands in the area. Wetlands may represent poor winter habitats for coyote. Nevertheless, Major and Sherburne (1987) reported, in western Maine, that ericaceous bogs were selected by coyotes during all seasons but less during winter (Ivlev's index 0.03) than spring and fall (Ivlev's index 0.42 to 0.70). However, home ranges of OP-coyotes remained significantly smaller than home ranges of KNP-coyotes after excluding the wetland areas. Thus, the higher proportion of wetland areas in KNP do not explain the difference in home range size we found. The fact that the size of the home range was negatively related with the percentage of forest regeneration areas may explain the difference in home range size between KNP-coyotes and OP-coyotes. Gese et al. (1988) also found a negative relationship between coyote home range size in Colorado, and the percentage of different types of habitats with the highest prey densities and available cover for bed sites and dens. At least in one of their two study sites, Mills and Knowlton (1991), reported an increase in coyote home range size as main prey (Black-tailed jackrabbit, *Lepus californicus*) density decreased.

The KNP area is characterized by a low human activity, especially during winter, and a lower level of anthropic perturbations resulting in a lower level of fragmentation. Several studies showed higher vulnerability of lagomorphs to predators as forest fragmentation increase (Keith et al. 1993, Villafuerte et al. 1997). Although snowshoe hare density was lower outside KNP, they may have been more vulnerable to coyote predation due to forest fragmentation. Consistently, Dumond et al. (*submitted manuscript*) found that coyotes were consuming more hare outside the Park during winter. OP-coyote winter diet was mainly constituted of hare outside KNP (occurence in 75% of the scats), while KNP-coyotes were relying on a more divers diet including snowshoe hare (44%), moose

(32%), beaver (21%) and small mammals (18%).

Fragmentation of forested habitat generally leads to higher vulnerability of inhabiting species, and higher concentrations of medium-sized generalist predators such as raccoon, skunks, foxes, and coyotes (Oehler and Litvaitis 1996). Therefore, the higher vulnerability of hare outside KNP may reduce the required area for a coyote to survive.

At least during winter, this would be consistent with the hypothesis that northern forested habitats with low human activity may represent suboptimal habitats for coyotes (Todd 1985, Crête and Lemieux 1994, Tremblay et al. 1998).

According to our telemetry data and field observations, four coyote families were estimated to use KNP. Consistently, Dumond (1997) estimated a coyote density of 8 coyotes/100km^2 during winter in KNP. Dumond and Villard (2000), found that the proportion of coyotes under 2 years old was very low in eastern New Brunswick (15.6%), and that the percentage of adult females with placental scares was only 42.9%. This suggest that the recruitement in this population was low. Also, KNP-coyotes extended their movements outside KNP-boundaries and thus were exposed to human-related mortality. Therefore, the hypothesis that a protected area such as Kouchibouguac national Park would act as a source for the local coyote population seems to be groundless. Moreover, these data support the hypothesis that human activities, and the resulting forest fragmentation, artificially maintain high coyote population densities.

The daily distance traveled by coyotes reported in our study area (20.2 km/24h) was higher than the winter average observed by Patterson et al. (1999) in Nova-Scotia (14.3 km/24h). Nevertheless, our data coincide with the annual average (20.2 km/24h) reported by Patterson et al. (1999).

Although minimal distances traveled were similar between KNP-coyotes and OP-coyotes, KNP-coyotes tended to travel greater distances when located outside KNP. Compared to OP-coyotes, the activity rate of KNP-coyotes was significantly lower and concentrated during the daylight hours. This could reflect a lower level of human persecution within KNP that allow coyotes to be more active during the daylight. A significant higher level of diurnal activity was also reported in a western coyote population after human persecution have ceased (Kitchen et al. 2000). Nevertheless, ungulates were more important in coyote

diet within than outside the KNP during winter (Dumond et al. *submitted manuscript*). This may have influenced the movements and the activity rate of KNP-coyotes that would be more inactive while feeding on ungulate carcasses (Gese et al. 1996).

Recommendations

Because human activities and particularly forest fragmentation seem to favor high coyote population densities, the management of coyotes should include appropriate forestry practices. Clear-cutting increase forest edges and may in turn result in higher prey vulnerability, and higher medium-sized carnivore densities. Different logging practices should be experiment in areas where high coyote population density represents a threat to other target wildlife populations.

It is important to mention that KNP does not seem to represent a demographic source for the local coyote population. Moreover, KNP apparently provides suboptimal winter habitat for coyotes because the lower level of habitat fragmentation may reduce snowshoe hare vulnerability to coyotes (Dumond et al. *submitted manuscript*).

Although ungulate carcasses may represent high quality food for coyotes, their availabilty is probably dispersed in the landscape, so that coyotes would require larger home ranges compared to coyotes living in areas of high hare vulnerability. For that matter, ungulate carcasses resulting from non-natural mortality (e.g. roadkills) should not be clumped but dispersed in the landscape when discarted.

For better wildlife management plannings, we need to understand coyote behavioral responses to landscape structure and human activities in the northeastern part of coyote distribution. Particularly, we need to understand the factors that promote variation in coyote diet and movements in forested landscapes with different logging practices and different levels of human disturbances.

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